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Mesozoic reptiles from the North Sea

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Four fossils of Mesozoic reptiles are described. Three of the fossils are attributed to Plesiosauria and one fossil can be attributed to an Iguanodontidae. The fossils were trawled from the bottom of the North Sea. These unusual catches most probably originate from the eastern coast of the United Kingdom and might have been transported to the seabottom by Pleistocene glacial action.

Keywords: Sauropterygia, Dinosauria, *Iguanodon*, Jurassic, Cretaceous, United Kingdom

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INTRODUCTION

Many hundreds of thousands of fossil bones from Miocene, Pliocene, Pleistocene and Holocene mammals have been collected from the North Sea bottom by fishermen and workers aboard suction dredgers. Some years ago the second author recognised two fossil bones in a private collection of a fisherman as reptilian like. These two fossils were stored as curiosities. The occurrence of another reptile vertebra towards the end of 1997 and especially the recognition at sea of a fourth reptilian fossil bone by a fisherman was the motivation for a more detailed study of these unusual catches.

FOSSILS AND LOCALITIES

The first two fossils (no. 759 and no. 861, Post collection, Urk, the Netherlands) were recognised during 1995 in a fisherman's private collection (mr P. de Jonge of 's-Heerenhoek, the Netherlands) and were collected by the fishing vessel ARM 17 (Arnemuiden) during 1990 and 1992. No. 861 was fished off the U.K. coast at the level of Whitby (Yorkshire); no. 759 was caught somewhere within the U.K. sector of the North Sea. The third fossil bears no number and belongs to the private collection of mr De Wavrin, Brussels, Belgium. This fossil was caught by the fishing vessel OD 6 (Ouddorp), also somewhere within the U.K. sector of the North Sea, during the month of November 1997. The fourth fossil (no. 2600, Post collection, Urk, the Netherlands) was discovered 15 February 1998 by the Urk fisherman mr A. Hoekman on board the vessel PD 43 (Peterhead). This fossil bone was collected on the southwest slope of the so-called Botney Cut (53° 52' N, 2° 45' E) at a depth of 33 metres below mean sea level along with many stones or boulders of an apparently U.K. origin.

DESCRIPTION AND IDENTIFICATION OF THE FOSSIL BONES

Sauropterygia
Plesiosauria
(Fig. 1)

Three specimens are clearly referable to Plesiosauria. However, two of them are dorsal vertebrae, on the basis of which it is difficult to reach a precise identification (see Brown 1981, for a review of the characters on which plesiosaurian taxa can be distinguished). Whether these vertebrae belong to the Plesiosauroidea or to the Pliosauroidea is uncertain. The third specimen is apparently an incomplete scapula which seems to be referable to the Pliosauroidea.

The unnumbered vertebra in the De Wavrin collection (Fig. 1 A,B,C) is identified as a posterior dorsal vertebra of a plesiosaur. The fossil is of a dark brown colour, with a rusty yellowish material filling the pores and cavities of the bony tissue. Although the surface of the bone has suffered some abrasion, so that the somewhat spongy bone tissue is visible in some areas, this vertebra still shows part of its neural arch, which is firmly fused to the centrum. The articular faces of the centrum are circular and slightly concave with a small pit in the middle (corresponding to the position of the fully closed notochordal canal). The ventral surface of the centrum is rounded, without any median keel, and it bears several large foramina. The lateral sides of the centrum are only very slightly concave anteroposteriorly; they bear a foramen at mid-height. The neural arch is incomplete, as it is broken just above the roof of the neural canal. The neural canal is oval in shape, because it is higher than wide; it is still partly filled with a yellowish-grey clayey matrix. The neural pedicels on both sides are massive and show the bases of broken transverse processes that apparently were directed upward and outward. The position of the transverse processes on the neural arch, not on the centrum, shows that this vertebra belongs to the middle or posterior part of the trunk.

Measurements
Width of anterior articular surface of centrum: 100 mm.
Height of anterior articular surface of centrum: 85 mm.
Length of centrum: 65 mm.

The vertebral centrum no. 759 (Post collection, Fig. 1 D,E,F,G) is a dorsal vertebra of a plesiosaur. The fossil is light brown in colour, apparently not heavily mineralised, and shows no remains of matrix. The neural arch is missing and the clearly visible sutural surfaces on the dorsal side of the specimen show that it was not fused to the centrum. Obviously this specimen is from a juvenile individual, which is confirmed by the persistent notochordal canal visible as a foramen in the anterior and posterior rounded articular faces of the centrum. Except for the slight depressions into which the notochordal canal opens, the articular faces are nearly flat. The ventral side of the centrum is well rounded, with only the slightest indication of a median keel, on both sides of which a distinct foramen occurs. The lateral sides of the centrum are concave anteroposteriorly, so that the centrum is slightly constricted. A small foramen is visible in the dorsal part of each lateral side. On the dorsal side the floor of the neural canal is strongly constricted between the excavated crescent-shaped sutural surfaces for the neural arch. As there is no evidence of rib facets or tranverse processes on the sides of this centrum, it clearly belongs to the middle or posterior part of the trunk.

Measurements
Width of anterior articular surface of centrum: 48 mm.
Height of anterior articular surface of centrum: 47 mm.
Length of centrum: 39 mm.

Specimen no. 2600 (Post collection, Fig. 1 H,I) is a massive rectangular flattened piece of bone which appears to be a part of a girdle element of a fairly large sauropterygian. The

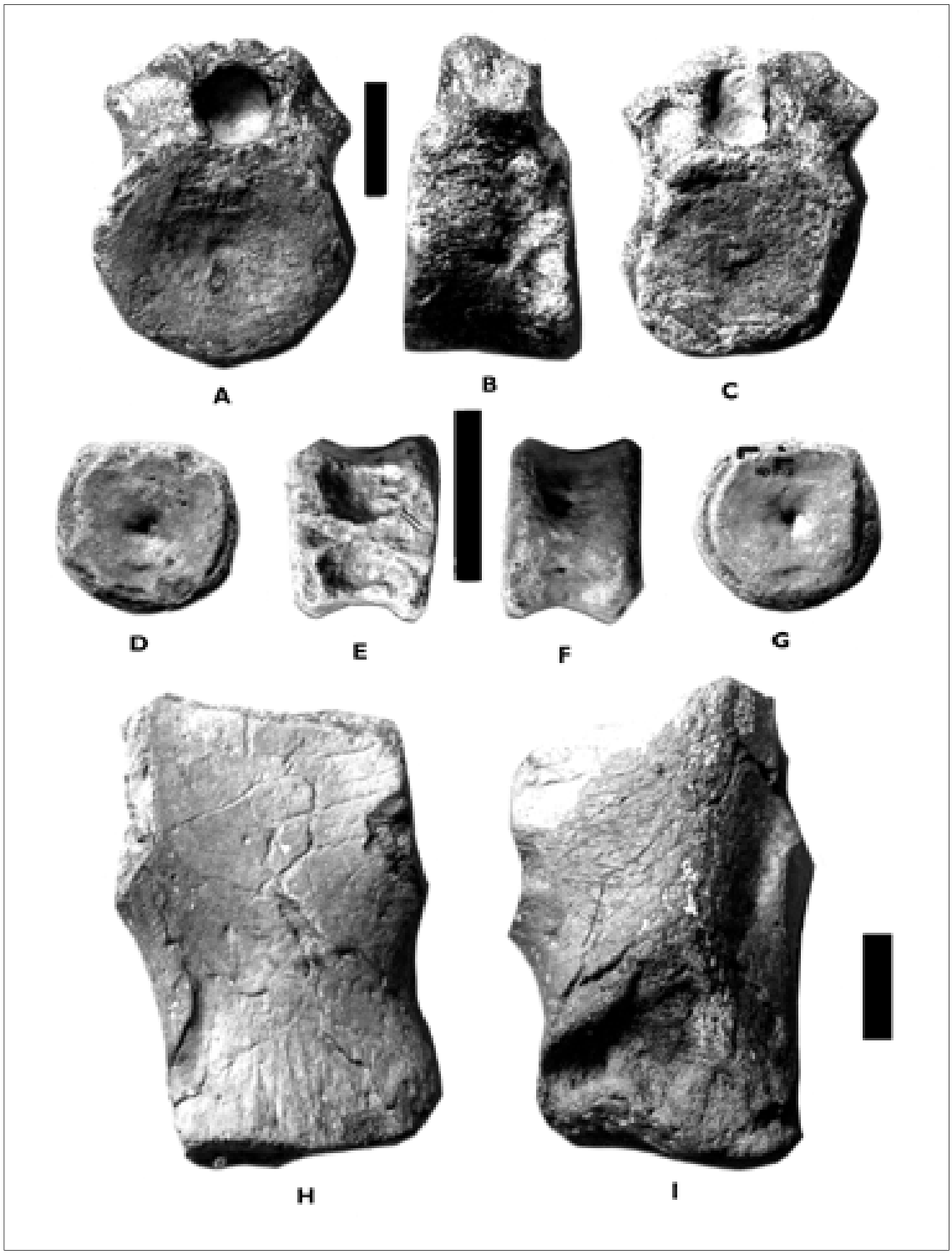

Figure 1 Sauropterygian bones of the North Sea. **A**,**B**,**C**: Plesiosauria, dorsal vertebra, De Wavrin collection, unnumbered, in anterior (**A**), left lateral (**B**) and posterior (**C**) views; **D**,**E**,**F**,**G**: Plesiosauria, centrum of dorsal vertebra, Post collection no. 759, in anterior (**D**), dorsal (**E**), ventral (**F**) and posterior (**G**) views; **H**,**I**: Pliosauroidea ?, fragment of right scapula, Post collection no. 2600, in dorsal (**H**) and ventral (**I**) views. Scale bars: 50 mm.

fossil is brown in colour; only a few patches of a fine-grained grayish matrix can be seen. Tubes on the surface are certainly of recent origin. The bone seems to have been originally triradiate, but two of the branches are broken. The remaining branch ends in an oval-shaped, slightly twisted articular surface. The shape of this specimen suggests that it is a fragment of a right scapula, in which case the above-mentioned surface would correspond to both the glenoid and the contact with the coracoid. One of the faces of the bone bears a strong ridge issuing from the articular surface. This appears to correspond to the ridge seen on the ventral surface of many pliosaur scapulae (Andrews 1913, Tarlo 1960). One of the slightly upturned broken branches of the bone, which issues not far from the articular surface, has a fairly thick almond-shaped cross-section and is probably the base of the dorsal process of the scapula. The other broken branch is thinner and is probably all that remains of the ventral plate.

The bone is too incomplete to warrant a reliable reconstruction, but its shape is reminiscent of the scapulae of the '*Liopleurodon* type' described and figured by Tarlo (1960). The scapulae of plesiosaurs, such as those figured by Andrews (1910) and Brown (1981), seem to show a more distinct angle between the glenoid surface and the articular surface for the coracoid. Therefore we tentatively refer this specimen to an indeterminate pliosaur.

Measurements
Length of preserved articular surface: 120 mm.
Width of preserved articular surface: 54 mm.

Dinosauria
Ornithischia
Ornithopoda
Iguanodontidae
cf. *Iguanodon*
(Fig. 2)

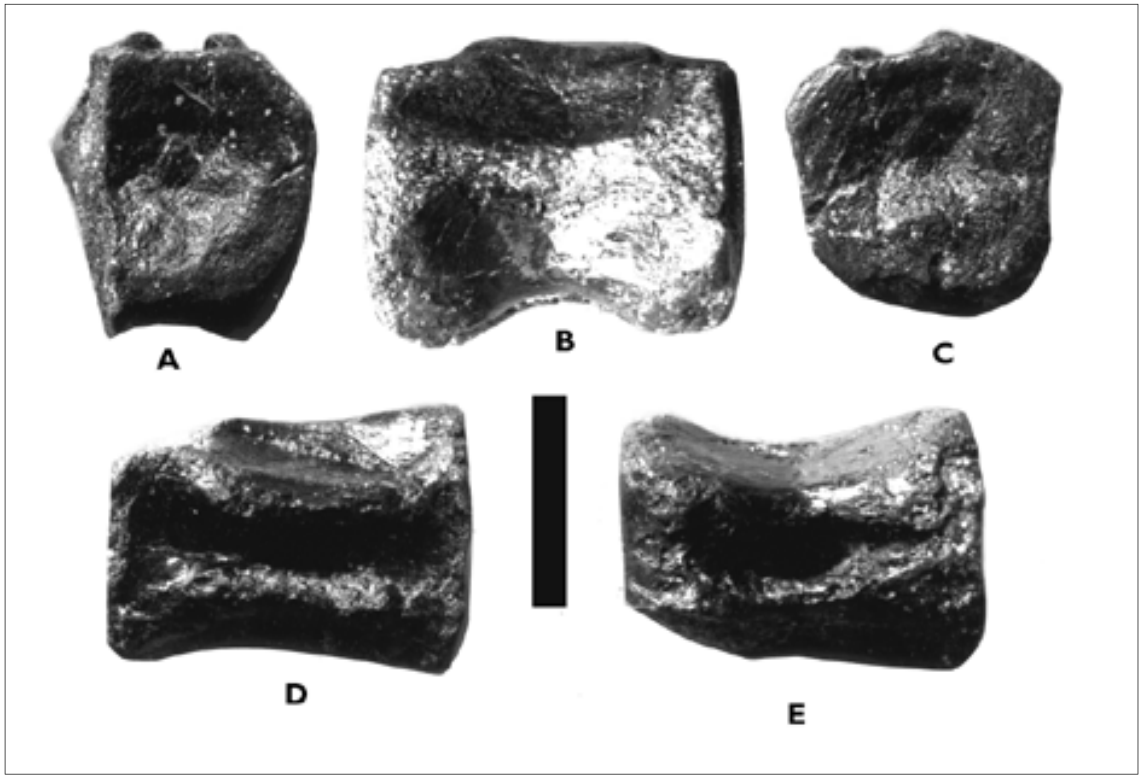

Figure 2 Dinosaur caudal vertebra (cf. *Iguanodon*) from the North Sea, Post collection no. 861, in anterior (**A**), left lateral (**B**), posterior (**C**), dorsal (**D**) and ventral (**E**) views. Scale bar: 50 mm.

The vertebral centrum no. 861 (Post collection) is identified as a caudal vertebra of a dinosaur. The fossil is black in colour; very little matrix is left, except for the light-coloured mineral grains in interstices of the bony tissue. Although its right side is damaged, and some abrasion is visible in several places, this vertebral centrum is fairly well preserved. It is relatively long and low, with well-marked chevron facets at both ends of the ventral face, which show that it is a caudal vertebra. The articular faces are moderately concave, with a subquadrangular outline, especially posteriorly. The lateral faces bear a well-marked longitudinal ridge, which is apparently a rudiment of a transverse process and indicates a fairly posterior position in the caudal series. The lateral faces being concave anteroposteriorly, the centrum appears constricted in dorsal and ventral view. The dorsal face of the bone shows the base of the pedicels of the neural arch, separated by the floor of the neural canal. The neural arch was obviously firmly fused to the centrum, which indicates an adult animal. The anteroposteriorly concave ventral side of the centrum shows two well-marked longitudinal ridges that link the anterior and posterior chevron facets. The ridges are separated from each other by a deep median groove, the depth of which has clearly been exaggerated by crushing. Comparison reveals strong resemblances between this specimen and the vertebrae of the middle part of the tail of ornithopod dinosaurs. By its size and morphology this bone is quite similar to mid-caudal vertebrae of Iguanodon. According to Norman (1980, 1986), however, the ventral surface of both *I. bernissartensis* and *I. atherfieldensis* from the Lower Cretaceous of Bernissart (Belgium) is flat rather than grooved as in the present specimen. As mentioned above, the depth of the median groove on the vertebra from the North Sea has clearly been exaggerated by crushing. Moreover, mid-caudal vertebrae of *Iguanodon* from the Hauterivian of Wassy, in the eastern Paris Basin, show a ventral median groove (Martin & Buffetaut 1992), so that the presence of such a groove on the North Sea specimen does not prevent its attribution to an *Iguanodon*-like ornithopod.

Measurements
Length of centrum: 88 mm.
Width of posterior articular surface: 66 mm.
Height of anterior articular surface: 66 mm.

It is worth mentioning here that the paleontological collection of the Natural History Museum (London) also contains a dinosaur vertebra from the bottom of the North Sea. It was part of the Owles collection and was purchased by the British Museum in 1874. Lydekker (1888, p. 206) mentioned it under no. 46292 as 'the centrum of an anterior dorsal vertebra; dredged off the Eastern Coast'. No further details are available about its origin. Dr. Gilles Cuny (University of Bristol) kindly examined and photographed the specimen for us. It is a rather worn vertebral centrum which does resemble the anterior dorsal vertebrae of *Iguanodon*. Barnacles are attached to its surface, which suggests it was not found at a very great depth. We mention it here as an additional instance of an iguanodontid-like vertebra from the North Sea.

GLACIAL ACTION AND THE GEOGRAPHICAL ORIGIN OF THE FOSSILS

The four fossils must originate from Jurassic or Cretaceous strata. However, in most of the southern and central North Sea the Jurassic or Cretaceous layers are nowhere exposed at, nor even subcrop beneath, the sea-floor (Laban 1995). In fact Jurassic and Cretaceous sediments and rocks are covered in this area with up to more than a thousand meters of Tertiary, Pleistocene and Holocene sediments. Only in a small area in front of the Yorkshire coast Jurassic and Cretaceous layers are reaching close to the seabottom (Cope *et al*. 1980). These layers are covered with boulderclay of Pleistocene origin. The only plausible explanation of Mesozoic fossils occuring on the bottom of the U.K. sector of the North Sea is glacial action and in fact this assumption is con-

firmed by the fact that these fossils are caught together with many boulders and other Mesozoic fossils like ammonites and bivalves of an apparently British origin.

Three or four periods of glacial advance have been assumed for the North Sea area (Oele 1971; Laban 1995). A pre-Elsterian glacial advance is still discussed for the North Sea; no real proof for its occurrence has been found to date. An Elsterian ice sheet covered with certainty a large part of the present North Sea . It is not (yet) sure from which direction its main ice flow originated. Still debated as well seems whether or not the U.K. was covered or partly covered by this ice sheet. The Saalian ice sheet covered most of north-eastern Europe. Although proof of this Wolstonian ice sheet has been found in East Anglia, most authors assume that this ice sheet did not cover large areas of the U.K. and very probably it did not enter at all eastwards into the present North Sea area. A massive Weichselian glaciation occurred in the U.K., Western Europe and on parts of the present North Sea bottom. Although most authors do agree that the water level in the Weichselian North Sea may have been more than a hundred metres below present mean sea level, there still exists no uniform opinion as to the real extent of these ice sheets. Most of the authors assume that there existed two main ice flows: one from the Baltic states and Norway and one from the U.K. (Ehlers & Wingfield 1991). Laban (1995) proved that the eastern-most tip of the the U.K. ice sheet just reached into the Dutch sector of the North Sea. Very probably this ice sheet originated from south-east and east England and moved east and southeastwards close to and into the present Dutch sector of the North Sea (Fig. 3). Therefore it seems safe to presume that the fossils were displaced from the original strata from the U.K. east coast by Weichselian ice masses.

DISCUSSION AND POSSIBLE STRATIGRAPHICAL ORIGIN OF THE FOSSILS

Unlike the the megalosaurid maxilla dredged up by a trawler from the Channel seabed off Portland, which apparently came from subjacent Kimmeridgian strata (Powell 1987), the bones of the Mesozoic reptiles of the North Sea are not found in situ. It is only clear that they must originate somewhere from or near the U.K. east coast. Also the remains of the Mesozoic reptiles are too fragmentary to warrant very precise identification. It is therefore difficult to assign them to a precise stratigraphic age, which in turn makes the search for the possible geological and geographical origin more difficult.

The likeliest source of the sauropterygian bones is either the Callovian-Oxfordian Oxford Clay or the Liassic, especially the so-called ‘Alum Shale’ of the Yorkshire coast. Both sources have yielded abundant remains of marine reptiles. The fossiliferous Liassic beds are well exposed along the coast of Yorkshire around Whitby (Benton & Spencer 1995). The Oxford Clay forms a long band stretching from Weymouth in the southwest to Yorkshire in the northeast (Hudson & Martill 1991). On the basis of the available specimens it is not easy to decide which origin is most likely. Preservation of at least no. 759 rather suggests the Oxford Clay. Of course, the three specimens may not come from the same rock unit.

The dinosaur vertebrae pose a different problem, because they indicate a relatively large *Iguanodon*-like animal. No remains of such dinosaurs have been found so far in the Liassic of Yorkshire. The Oxford Clay is not a very likely source either, since the only ornithopods recorded from it, the camptosauriid *Callovosaurus leedsi* and a hypsilophodontid, are small forms (Martill 1988). The likeliest source for *Iguanodon* remains would seem to be the Early Cretaceous Wealden of southern England (Benton & Spencer 1995), but this part of Great Britain was probably not glaciated

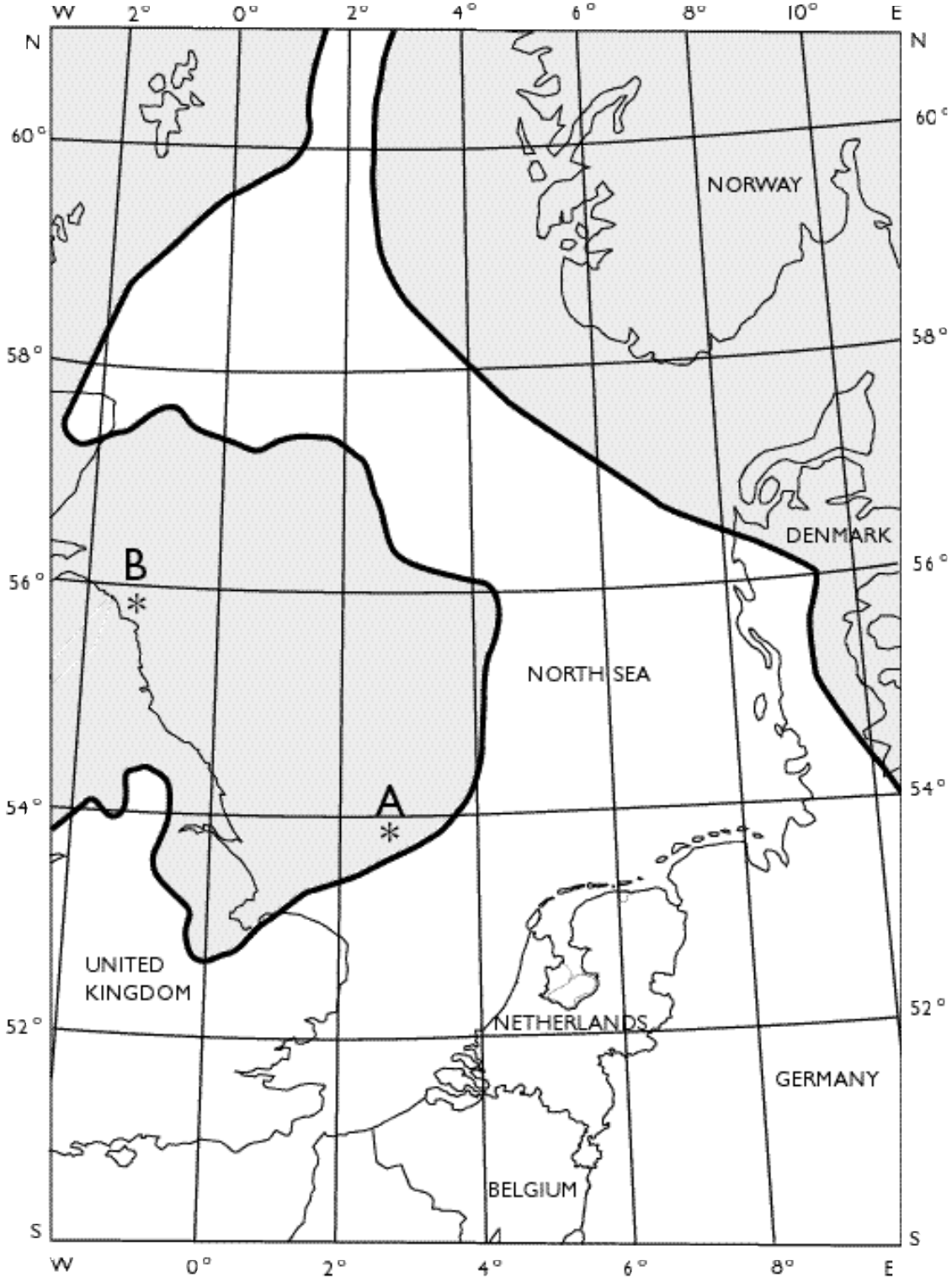

Figure 3 Extent of the Weichselian ice sheet in the North Sea region, after Ehlers & Wingfield 1991. With location (**A**) of fossil no. 2600 and (**B**) of fossil no. 861. [map graphics: Jaap van Leeuwen]

during the Pleistocene. So it is difficult to conceive how dinosaur bones from the Wealden could have been transported to the bottom of the North Sea (especially if we bear in mind the direction of the iceflow during the Weichselian). Wealden beds do extend to the seabed of the English Channel between the Weald in England and the Boulonnais in France, but not to the North Sea (Rawson *et al.* 1978). There are few possible sources for bones of large iguanodontids in northern England. A partial iguanodontid skeleton has been found in the Early Cretaceous marine 'Speeton Clay' of Yorkshire (P.M. Barrett pers. comm.), but such occurences are exceptional. Thus, the 'Speeton Clay' does not seem a logical source. For the time being the exact source of the dinosaur material of the North Sea must therefore remain uncertain.

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